DESCRIPTION OF A 30-TON HORIZONTAL DUPLEX HAMMER.

BY MR. JOHN RAMSBOTTOM, OF CREWE.

The Hammer described in this paper arose out of the writer's belief that it was necessary to provide some means more powerful than any before used in England, and at the same time convenient and handy, for the forging of steel in large masses. His attention was first drawn to this question when he was engaged in laying out the Bessemer Steel Works of the London and North Western Railway at Crewe. The first intention was to put down a 30-ton vertical hammer of the ordinary kind; but as this would have required an anvil of 300 tons, the practical difficulty and cost of dealing with so large a mass suggested to the writer that the principle of *action and reaction* might afford a solution of the problem. Hence arose the conception of two hammers acting in opposite directions; and as a matter of convenience it seemed better to lay them on their side and cause them to operate horizontally upon a bloom placed between them. As this idea grew into form it appeared to present advantages both in economy and convenience sufficiently important to warrant the construction of an experimental hammer of 10 tons. This when brought into operation proved to possess the advantages expected; and in consequence the writer designed and laid down the 30-ton hammer which forms the subject of the present paper.

General Description.—The Duplex Hammer is shown in Figs. 1 to 4, Plates 64 to 66, and consists of two similar cast-iron blocks A A, forming the hammer tups, which are placed with their heads towards each other; each is mounted on eight wheels, and connected at the hinder end by a piston-rod B to a piston working in a cylinder C of 38 inches diameter and 42 inches stroke. Each block with its piston and rod weighs 30 tons. The steam pipe D occupies a position midway between the two cylinders C C, and two branches E E are carried from it, one to each cylinder, so that each receives an equal supply of steam. The mean pressure throughout the stroke is 30 tons on each piston; and the effect is consequently the same as that which would be produced by the action of gravity upon the hammer tups through a fall equal in length to the stroke. The wheels F F run on steel-headed rails, bolted down upon the cast-iron girders G G, on the hinder ends of which the cylinders rest and are bolted down by their flanges.

Hammer Tups.—For convenience the hammer tups are each cast in two pieces, jointed transversely at the centre, and held together by two wrought-iron hoops H H shrunk on bosses cast on each side of the half-tups for this purpose. Two wrought-iron dowel pins I I, Fig. 1, 4 inches diameter and 13 inches long, driven half their length into each half tup in a longitudinal direction, prevent any independent side play.

Wheels.—The wheels F F are of cast iron, chilled on the circumference and flanged; they are 18 inches diameter, and the centre hole is $6\frac{1}{2}$ inches diameter, reduced by a brass bush to $5\frac{1}{4}$ inches diameter, as shown in Fig. 3; they run loosely on Bessemer steel axles, which pass right through the bodies of the tups. These axles are $5\frac{1}{2}$ inches square in the centre, as shown in Fig. 1, and are turned at the ends to fit the wheels, the journals being thus $5\frac{1}{4}$ inches diameter and 15 inches long. The holes in the body of the tups are $7\frac{1}{2}$ inches square, and the axles are secured in them by wood packing J, Fig. 3, and iron wedges driven in at each end of the holes; this is considered better than bored holes and an absolutely rigid fit.

Piston Rods.—The piston-rods B B are of Bessemer steel, 8 inches diameter. They each carry at the forward end a head K, Fig. 1, 16 inches diameter and 8 inches long, forged solid upon the rod, as shown to a larger scale in Fig. 5, Plate 67; this head enters a hole in the hinder end of the tup A, $16\frac{1}{2}$ inches diameter and $18\frac{1}{2}$ inches deep. A wrought-iron washer-plate L, 2 inches thick, is passed along the piston-rod from the other end, and is fastened by studs to the hinder end of the tup, the diameter of the stud circle being $21\frac{3}{4}$

inches. A packing of india-rubber 1-8th inch thick and wire-gauze in alternate layers is interposed between the head of the piston-rod and the tup; this packing is 8 inches thick in front of the head, and 3 inches thick behind, between the head K and the washer-plate L. One of Ramsbottom's pistons of cast steel is fastened to the other end of the piston-rod in the ordinary manner, as shown in Figs. 1 and 2.

Valve Chests.—The valve chests M M, Figs. 1, 2, and 4, are cylindrical, and are shown to a larger scale in Figs. 6 and 7, Plate 68; they are both on the same side of the hammer, so that the cylinders are right and left handed. The valves N N are the ordinary cylindrical valves, turned to fit accurately in the chests. The ports consist of holes 1 inch wide by $1\frac{1}{4}$ inch long, placed in a circle all round the valve chest, as shown to a larger scale in Fig. 8; thus an area of 36 square inches is obtained with a length of valve stroke of only $3\frac{1}{2}$ inches. The steam pipe E is brought vertically upwards under the valve chest, which it joins in the centre of the bottom side. One of the lengths of this pipe has a horizontal branch O, containing a counterpoising lever P; a link Q fastened to the short arm of the lever passes vertically up the centre of the pipe E, and is provided with a rounded head 5 inches broad and 1 inch long, which fits into a recess made for it in the underside of the valve N: on the long arm of the lever P a weight R is so fixed that the weight of the valve is exactly balanced, and friction is thereby avoided. The two valves are each connected by a series of links to a shaft S, Figs. 1, 2, and 3, passing below the ground level; and a handle T on this shaft is brought up above the ground in such a position that the attendant working the valves is in full view of the hammer faces.

Connecting Screw.—In order to ensure the two hammer tups A A moving simultaneously, and striking the bloom exactly at the same instant, a steel screw-shaft U, Figs. 1, 2, and 3, is carried underneath the tups in the centre line of the hammer, and is provided with a right-and-left-handed thread, on which work two brass nuts V, one fixed to each tup, the screw-shaft being free to turn in fixed bearings carried by the foundation girders G G. If the screw-shaft were turned round independently, it would draw the two tups together at an equal speed, making them meet exactly in the centre, or it would cause them to separate at an equal speed; consequently when the two tups are moved each by its own piston, any difference in the rate of their motion is prevented by their constant connection through the screw-shaft. This shaft is $4\frac{1}{2}$ inches diameter in the solid and 6 inches diameter outside the threads, as shown to a larger scale in Figs. 9 to 12, Plate 69; the pitch of the threads is 9 inches, and there are six threads to the pitch. The nuts V are each cast in four quarters, the planes of division being both vertical, one tranverse and the other longitudinal; the wear is taken up in both directions by wrought-iron wedges provided for this purpose, with adjusting set-screws X X; the total length of each nut is 24 inches. Each end of the screw-shaft U abuts on a brass step Y, Figs. 9, 12, and 13, which is held between two snugs on a cast-iron block fixed transversely between the girders G G. These steps are adjustable by means of wrought-iron tail-screws Z with lock nuts, as shown in Figs. 9 and 12. If one of the hammer tups had a tendency to over-run the other, it would cause end-play in the screw-shaft U, and the fault would be shown by the greater wear of the step Y at the further end; and consequently the fact that the two steps wear equally proves that there is no tendency to end-play in the shaft, and therefore that the motion of the one tup balances that of the other.

Girders and Foundation.—The two pairs of girders G G, Fig. 1, which carry the hammer tups and cylinders, rest at their hinder ends directly on the stone foundation, and at their forward ends upon another pair of girders P P, Figs. 1 and 3, supported on the stone foundation, one on each side of the centre line of the hammer; the foundation being lower at the centre than at the two ends, as shown in Fig. 1. The foundation consists merely of brickwork laid on the natural clay of the district, $2\frac{3}{4}$ feet thick at the centre and $5\frac{1}{2}$ feet thick at the two ends, with $2\frac{3}{4}$ feet of stone on the top of all, as shown in Figs. 1, 3, and 4. The girders are held down upon the stone by long bolts passing through the stone and brickwork, Figs. 3 and 4.

Ingot Trucks and Rocking Table.—The ingots while being hammered are held between the two hammer faces in trucks designed for the purpose. These rest on a rocking table W, Figs. 1 and 2, to which a slight tilting movement can be given by the attendant, so as to keep the ingot always in the centre between the hammer faces, and ensure its being struck by both hammers simultaneously. The table is formed of a cast-iron plate W, 22 inches wide and about 17 feet long, cast with a half-round projection on the underside all along the centre, which rests in four half-round bearings R R, Figs. 14 and 15, each 8 inches long, placed in the centre line of the cast-iron plate W and transversely to the hammer. The plate W is connected by linkwork with a handle Q, Figs. 1 and 2, placed in convenient reach of the attendant, for tilting the table slightly as may be required. The upper side of the table is grooved to admit the wheel flanges of wagons of 18 inches gauge, as shown in Figs. 15 and 16.

Truck for Ordinary Ingots.—The truck employed for supporting the ordinary description of long narrow ingot is shown in position between the hammers in Figs. 1 and 2, and to a larger scale in Figs. 14, 15, and 16, Plates 70 and 71. It consists of a carriage of boiler plate A, Fig. 14, 12 feet long and 19½ inches wide, running on four cast-iron wheels. The ingot B is held between two centres C C, carried in two headstocks D and E, in a manner similar to that in which a shaft is held in a lathe. One of these headstocks D is bolted to the bed of the carriage A; the other E is free to slide upon it. The gradual extension in length of the ingot during the hammering is provided for in the following manner. A central screw-shaft F F runs from end to end of the carriage below the headstocks; to the underside of the moveable headstock E is attached a crossbar G, having an opening in the centre to admit the free passage of the screw F. A short distance behind this, between the side pieces of the crossbar G, a wrought-iron nut I is placed upon the screw, and is prevented from turning round by wings on each side, which project underneath the side pieces of the crossbar G. A helical spring J is wound round the screw-shaft between the nut I and the crossbar G, which are prevented from separating beyond a certain distance by two bolts passed through each. At the forward end of the carriage a crossbar H, Fig. 15, bolted to the frame, carries two small wooden break-blocks, which act against the face of a spur-wheel K keyed on the end of the screw-shaft F. The pressure of the spur-wheel against the break-blocks is regulated by a transverse laminated steel spring L, Fig. 16, fixed at the other end of the carriage; on this tail-spring the hinder end of the screw-shaft F abuts, a brass step being interposed between the end of the shaft and the steel plates.

When a blow is delivered, the consequent extension in length of the ingot B causes the moveable headstock E, and with it the crossbar G, to slide backwards along the bed and compress the helical spring J. The reaction of this spring against the nut I forces the screw-shaft F endways, deflecting the tail-spring L. The pressure of the break H at the forward end being thus reduced, the screw-shaft revolves, allowing the nut I to slip along it, until the reaction of the tail-spring L restores the pressure on the break-blocks and prevents all further motion. For enabling the attendant to adjust the moveable headstock E to any required length of ingot before the hammering, and for admitting of the easy removal of the ingot when finished, the spur-wheel K on the forward end of the screw-shaft F is made to engage with another spur-wheel to which handles M are affixed, Fig. 15; a set-screw at this end acting on the screw-shaft removes all pressure from the break, and the shaft is then easily turned round as required. This truck is moved backwards and forwards on the rocking table W by hydraulic power.

Tyre Truck.—Another truck has been constructed for holding the conical ingots used in the manufacture of solid weldless steel tyres. This is shown in Figs. 17 to 21, Plates 71 and 72. It consists of a carriage of boiler plate A, placed upon the rocking table W, and carrying two pairs of rollers N N and P P, on which the conical ingot B lies with its axis horizontal, Figs. 18 and 19. One pair of these rollers N N, carrying the large end of the ingot, are $11\frac{1}{4}$ inches diameter by 9 inches length and $3\frac{1}{4}$ inches tapered, and remain fixed in position. The other pair of rollers P P are 9 inches diameter and $1\frac{1}{2}$ inch thick, and are carried in a wrought-iron frame Q, which slides vertically within wrought-iron guides, and is supported by a long wrought-iron wedge I. This wedge, which is 6 feet 10 inches long, is driven home at the commencement of the hammering, and is gradually drawn out so as to lower the supporting rollers P P by degrees, and accommodate their height to the increasing diameter of the centre of the ingot B during the hammering. The rate of withdrawing the wedge I is regulated by the attendant, who has thus complete facility for adjusting the ingot constantly to its true level between the two hammers with as great accuracy as if he were holding it by hand. The taper in the fixed rollers N N allows for the slight increase in diameter of the base of the ingot, which advances downwards towards the small ends of the rollers as the hammering proceeds. The ingot is continually turned round upon these rollers during the hammering by means of ordinary pinch bars. In the centre of the frame Q is a socket S, into which fits the stalk of a small mushroom turntable T, Fig. 17; the ingot is placed on this turntable with its axis vertical, for hammering all round the circumference, and it is easily turned round between each blow by means of an ordinary spanner. The truck A is kept in position on the rocking table W by projecting studs which fit into the grooves on the table.

Truck for Bars.—Another truck, shown in Figs. 22 to 24, Plate 73, is used for supporting ingots for bars. In this the bar B rests on six rollers carried in a boiler-plate frame A, which is placed on the rocking table W between the hammer faces, and kept in position by projections fitting into the grooves of the table; the rollers are placed one behind another along the length of the frame A. The two central rollers C C are 5 inches diameter and $14\frac{3}{4}$ inches long; the rest are 7 inches diameter and $14\frac{3}{4}$ inches long. The ingot B is shifted endways along the rollers by means of ordinary pinch bars.

Truck for Long Shafts.—In the forging of long shafts the work is supported on a pair of trucks A A, one at each end of the shaft B, as shown in Figs. 25 to 27, Plate 74. These trucks are exactly alike, each carrying two cast-iron rollers C C, Fig. 25, between which the shaft B lies. In order to retain the axis of the shaft always in the centre line of the hammer, whilst its diameter continually decreases, the supporting rollers C C, which are 6 inches diameter and 2 inches wide, are carried in a cast-iron frame D that can slide upon the body of the truck A up an incline of 1 in 4. A screw E fastened at the upper end to the body of the truck, and engaging with a nut in the sliding frame D, enables the attendant to adjust the height of the rollers and the shaft between them, as may be required from time to time. The two trucks are prevented from separating from each other by a wrought-iron link G. The whole runs on eight wheels, and is moved to and fro on the rocking table W by hydraulic power.

Peel Bar.—The ordinary method of lifting ingots out of the furnaces and carrying them to the hammer is to make use of a peel bar as a lever, on one end of which is the ingot, and the other end is either weighted or held down by a number of men, the fulcrum being supported by a chain from a crane or beam overhead. Instead of the chain, a curved wrought-iron link A is employed by the writer, as shown in Figs. 28 and 29, Plate 75; the peel bar B is wedged fast in the socket C in the link, and its weight is counterbalanced by the adjustable weights D at the outer end of the curved link A. By this means the point of support E of the whole is brought vertically above the ingot G, so that the carrier is always in equilibrium whether loaded or unloaded; and when the peel bar is run into a furnace and underneath an ingot, the point of support E is over the roof of the furnace and vertically above the ingot. By this arrangement one man at the end of the peel bar is enabled readily to handle an ingot of any weight, as he has merely to guide it in its progress to the hammer.

Character of Work.—To show the character of the work done by this duplex hammer it may be mentioned that, in drawing down a crank-axle ingot from its cast size of 20 inches × 24 inches and 3 feet 5 inches long to the form of a slab $11\frac{3}{4}$ inches × $21\frac{1}{2}$ inches and 5 feet 10 inches long, 312 blows are delivered. Of these blows 84 are light and are merely finishing blows, the preceding 228 being sufficient to do all the heavy part of the work, and these are delivered at the rate of 48 per minute with a stroke of rather more than 2 feet for each tup. The total time occupied is about 25 minutes. The slab when finished is slightly round at the ends, the length of the axis being a few inches greater than that of the surface, thus showing clearly that the blows penetrate quite to the centre of the ingot. The appearance of some defective crank-axle ingots which were broken when cold confirms this view, the metal being found to be of the same texture throughout—as continuous and solid in the centre as at the surface.

Chief Advantages.—Among the chief advantages which this form of hammer possesses are the following:—

It requires no anvil, the whole moving force of each hammer tup being balanced by the one opposed to it. Hence the cost of laying down and afterwards of occasionally lifting an anvil is avoided. A comparatively shallow foundation is required, a matter of great importance where drainage is difficult.

The action is equivalent to that of a vertical hammer with an anvil of infinite weight. Comparing it with a single 30-ton vertical hammer, it is evident that each block weighing of itself 30 tons has only to be moved through one half the space in order to produce the same effect; a greater number of blows can therefore be delivered in the same time. The blows being given simultaneously on opposite sides of the bloom, meet in its centre, and the resistance due to the inertia of the mass operated on is reduced by one half. The blows being in opposite directions counteract each other; hence no vibration is produced, and consequently no damage is done to the surrounding buildings and machinery.

The hammer is therefore an economical instrument both in first cost and cost of maintenance. In working it will be seen that the scale can fall away quite freely from the bloom, and also that there is great ease in the manipulation, and consequent accuracy in the forging of large masses: for instance the upsetting of a long crank-shaft can be performed with ease, an operation of great difficulty under the ordinary vertical hammer. It thus appears that the hammer will be specially convenient for the forging of guns and other long and heavy articles, more particularly since it can be made of larger dimensions at a comparatively small increase of cost. It may be conveniently worked in conjunction with a vertical hammer; by which means forgings that require two kinds of treatment may be easily dealt with. Also it can be used in buildings which from want of height could not contain a vertical hammer of the same effect.

The PRESIDENT remarked that he had seen the horizontal duplex hammer at work at Crewe, and it was certainly one of the most ingenious pieces of mechanism that he had ever seen, comprising a number of novel mechanical contrivances, every one of which was worked out in a most complete manner. The work turned out by the hammer was perfect, thoroughly sound and well finished in all parts; and having seen the working of the hammer on several occasions, after it had been in use for a considerable time, he understood that not the slightest trouble had been experienced in using it. Such a machine he thought must speedily come into general use, wherever forgings of considerable size had to be dealt with. He enquired how long the hammer described in the paper had now been at work.

Mr. RAMSBOTTOM replied that the present 30 ton hammer described in the paper had been at work nearly five months; and the previous 10 ton experimental hammer had been working constantly for about three years. The object he had aimed at in designing the horizontal duplex hammer had been to get a very powerful hammer at comparatively little cost, and with as little vibration as possible to the buildings and works; at the same time it was necessary for the hammer to be so arranged as to be useful not only for the heaviest forgings, but also for ordinary work. In the working of steel forgings in particular, his own experience had led him to the conclusion that the ordinary modes of working were very faulty, in consequence of not putting work enough into the mass of metal operated upon; and he considered that up to the present time there had been no means at all proportioned to the work to be done. The result was that the skin of the metal was too much hammered and the centre too little, so that the external portions became unduly drawn out, which caused the centre parts to be torn asunder and thus rendered unsound. This was in consequence of the forging not being performed by hammers with sufficient moving mass; and he did not believe that the desired effect of blow could be attained by mere velocity, nor that the absence of a sufficient mass in the hammer itself could be compensated for by increasing the speed of the hammer. What was wanted was a blow somewhat approaching a squeeze, and this could not be obtained by velocity, but only by the adoption of a heavier mass.

The horizontal duplex arrangement of the hammer however, notwithstanding the greatly increased weight of the masses put in motion, admitted also of great rapidity of action, in consequence of the strokes of the two hammer-blocks being made simultaneously, so that what was in fact a 4 feet stroke was got by moving each hammer only 2 feet. In this way he had obtained as many as 48 blows per minute from the 30 ton hammer, a greater number than could be obtained from a 5 ton vertical hammer working alongside and supplied with steam from the same boiler. They were thus enabled to get through the work while it was hot, which in itself was a point of importance in respect to economy. Another advantage of the heavier hammer was that the original steel castings could be forged in larger masses, and worked down to the desired shape with greater economy and better effect than under a lighter hammer. Although the work to be done at Crewe was in general not of a heavy character, the heaviest forgings being those for locomotive crank-axles, yet he did not think the 30 ton hammer now employed was larger than was required for effectually performing the work.

Mr. C. Cochrane observed that in the truck for ordinary ingots (Plate 70) the work was carried upon a pair of centres like lathe centres, and there appeared a great possibility of its dropping out under the blows of the hammer. He enquired whether any such accident had occurred, and in what manner the original centre holes were made in the two ends of the ingot for fixing it on the centres, so as to be large enough for holding it securely.

Mr. Ramsbottom replied that it had only once happened that the work dropped out from between the centres supporting it; and the accident occurred in consequence of the breakage of the helical spring (J, Plate 70) by which the moveable headstock was kept in position. Very slight centre-holes were found sufficient, which were made with a centre punch in the usual way by a blow from an ordinary sledge hammer; and there was found to be very little tendency for the work to get out, when once fixed on the centres of the truck. The metal seemed during the hammering to spread lengthwise to a slight extent round the centres, thus making the centre holes deeper; and it was a curious circumstance, which he had not been able to account for, that the centre points themselves were found to become more pointed, instead of being made more blunt by the effect of the hammering as might have been expected; this was the case more particularly with the centre in the fixed headstock.

The various trucks supporting the different sorts of work during the hammering were at present he considered the least satisfactory part of the arrangement, and it was in these that further improvement was most desired. The simplest and most effective of the plans yet tried was the six-roller truck used in forging long bars (Plate 73); but this was of course not available for general roughing-down, for which a sort of centre carriage was required, more like those used for holding the ordinary ingots (Plate 70) or the tyre blooms (Plate 72). The general practice with the duplex hammers, even in forging long bars, was to finish the forging from end to end in a single heat, so as to prevent the waste of skinning the iron over with a coat of oxide by a second heating. In this way also a great deal of time and skilled labour was saved, as well as the fuel required for a second heat.

The PRESIDENT enquired whether the cylinders of the hammer were provided with steam jackets; and also whether there was found to be any difficulty from wear of the stuffing-boxes.

Mr. RAMSBOTTOM replied that the cylinders were not steam-jacketted, but the condensed water was got rid of in the usual way by blow-off cocks. He had not experienced any trouble from wear of the stuffing-boxes, as the piston-rods were so thoroughly guided.

The PRESIDENT moved a vote of thanks to Mr. Ramsbottom for his paper, which was passed.

The PRESIDENT proposed a vote of thanks, which was passed, to General Morin and the authorities of the Conservatoire Impérial des Arts et Métiers, for their kindness in granting the use of the Lecture Theatre for the purpose of the meeting, and the facilities they had afforded in connection with the meeting; and also to the Honorary Local Secretary, Mr. Henry Chapman, for the very efficient and valuable assistance rendered by him in promoting the success of the meeting.

The Meeting then terminated; and in the evening the Members and their friends, with a number of guests invited for the occasion, dined together at the Trois Frères Provençaux, Palais-Royal, in celebration of the meeting of the Institution in Paris.

On Friday, 7th June, the Members visited the Observatory, upon the obliging invitation of the astronomer royal, M. Leverrier, who conducted them over the building and explained the construction and action of the principal instruments employed in the astronomical observations.

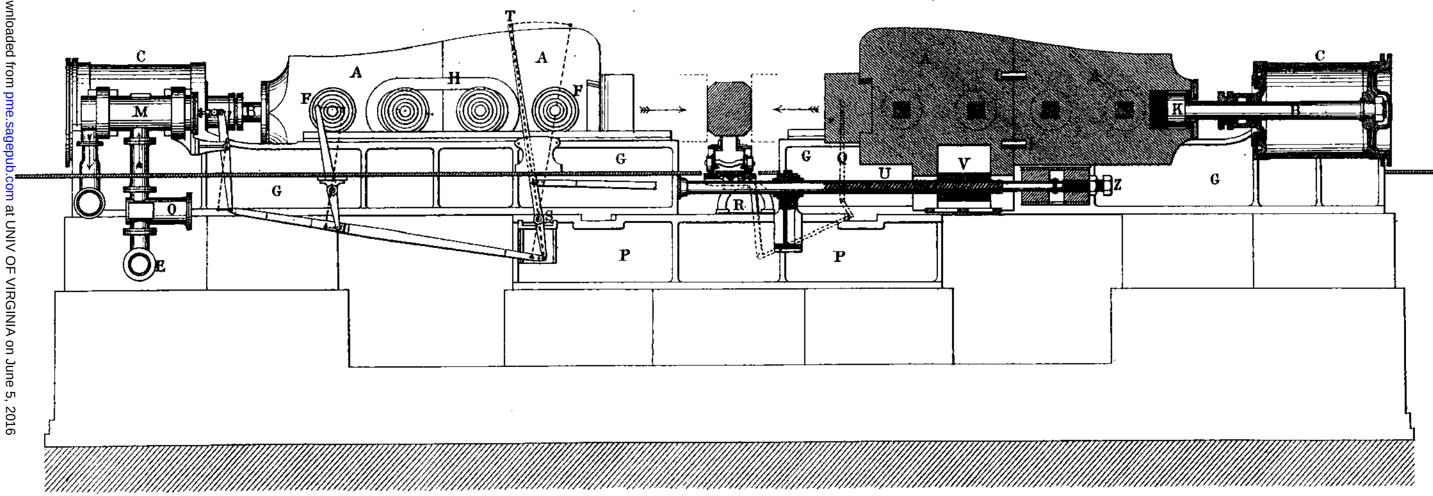
The Members then visited the Artesian Well Borings in progress of execution by M. Dru at Butte-aux-Cailles and at M. Say's Sugar Refinery, the description of which had been given in the paper read by M. Dru at the meeting on the previous day. At Butte-aux-Cailles a breakage of the boring rod had occurred shortly before the arrival of the Members, and they had thus an opportunity of witnessing the process adopted for recovering the broken portion left at the bottom of the bore-hole, by lowering a conical socket filled up on the underside with wax, to take an impression of the fractured end, preparatory to sending down a conical screwed socket, to screw upon the broken end for bringing it up. At the Sugar Refinery the boring was seen in progress, with the reaction tool liberated by the shock produced at the top of the stroke.

The Members were also shown the several processes of the sugar manufacture,—the boiling of the raw material, the separation of the liquid molasses and the drying of the brown sugar by centrifugal action in perforated cylinders revolving at a high speed, the clarifying of the white sugar, and the drying of the white sugar cones in heated rooms by the aid of exhausting pipes communicating with each cone.

A number of Engineering establishments and other works in Paris and the neighbourhood were also opened to the inspection of the Members during the days of the meeting.

HORIZONTAL DUPLEX HAMMER.

Fig. 1. *Side Elevation and Longitudinal Section of* 30 *ton Horizontal Duplex Hammer.*

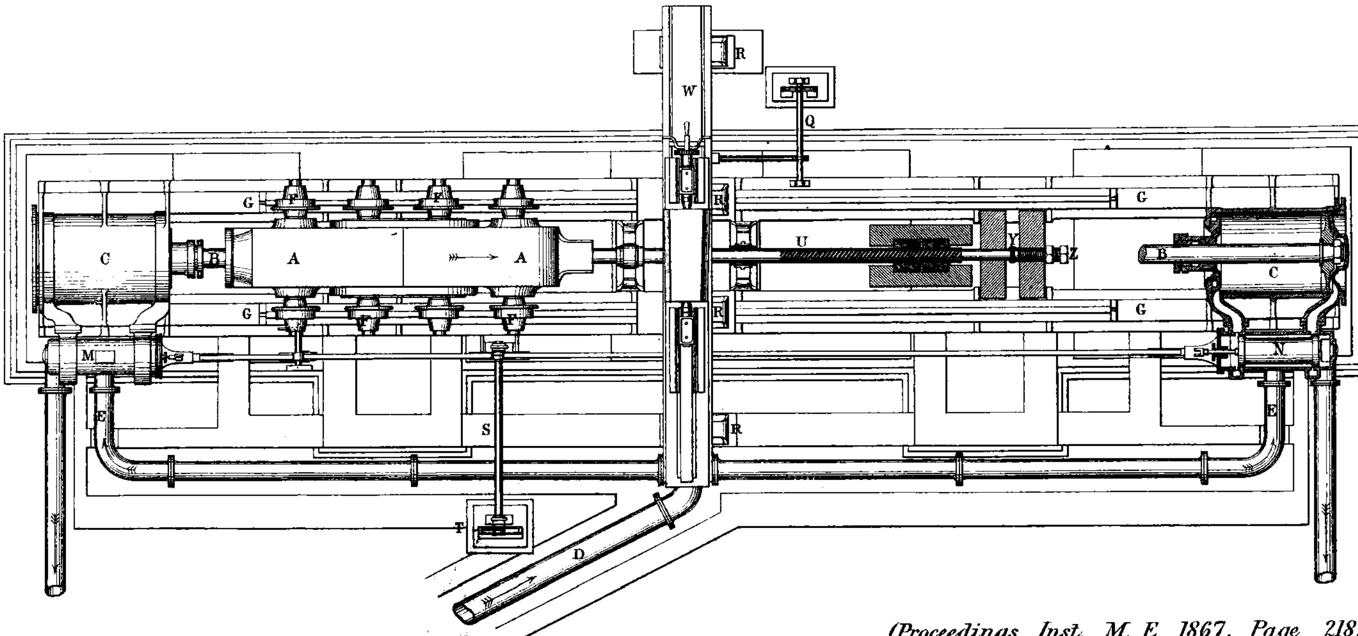


(Proceedings Inst. M. E. 1867. Page 218.)

Scale 1/80 th — 10 5 0 10 20 30 *Feet.*

HORIZONTAL DUPLEX HAMMER.

Fig. 2. *Plan and Sectional Plan of* 30 *ton Horizontal Duplex Hammer.*



(Proceedings Inst. M. E. 1867. Page 218.)

Scale 1/80th 10 5 0 10 20 30 *Feet.*

HORIZONTAL DUPLEX HAMMER.

Fig. 3. *Transverse Section through Hammer Tup.*

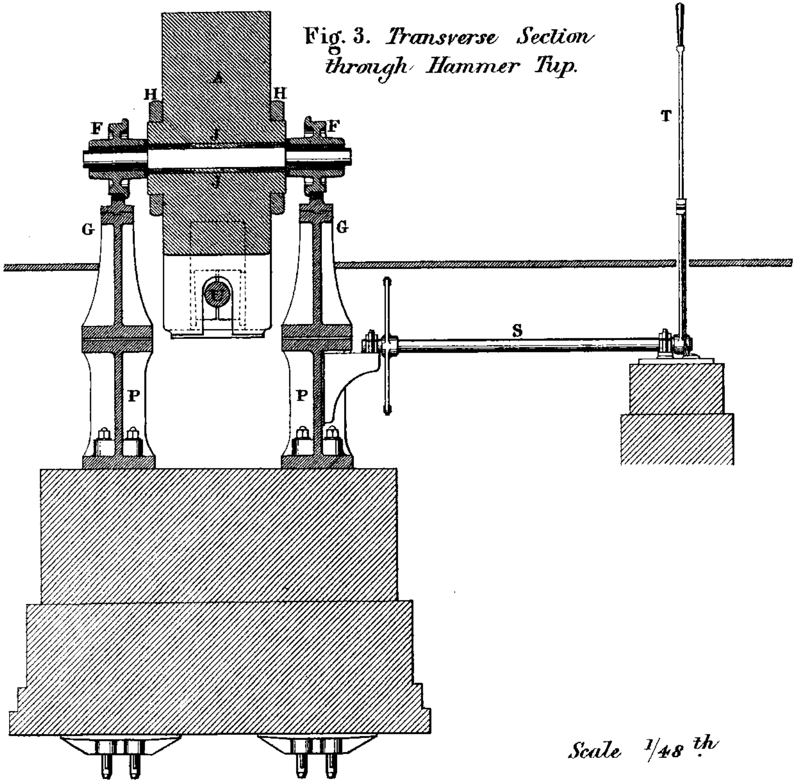
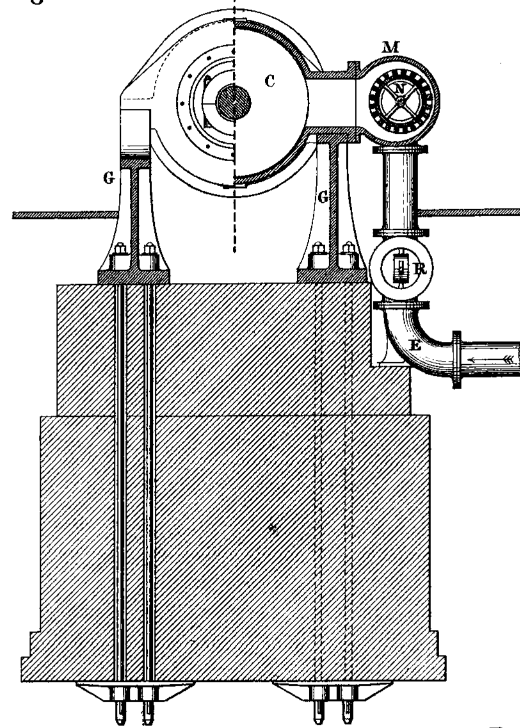


Fig. 4. *Transverse Section through Cylinder.*



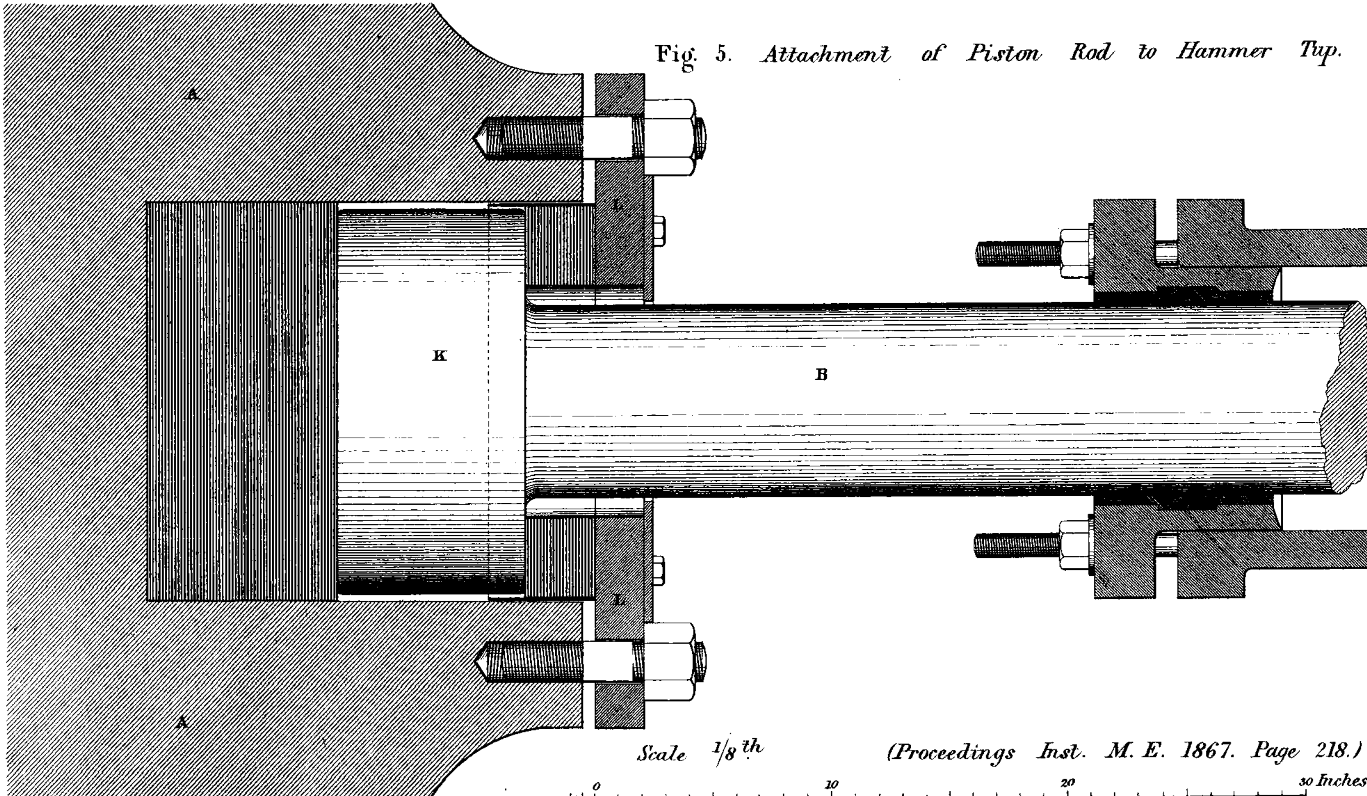
Scale $1/48^{th}$

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Feet.

(Proceedings Inst. M.E. 1867. Page 218.)

HORIZONTAL DUPLEX HAMMER.

Fig. 5. *Attachment of Piston Rod to Hammer Tup.*



Scale 1/8 th

(Proceedings Inst. M. E. 1867. Page 218.)

HORIZONTAL DUPLEX HAMMER.

Valve Chest and Valve.

Fig. 6. *Longitudinal Section.* *Scale 1/24th.*

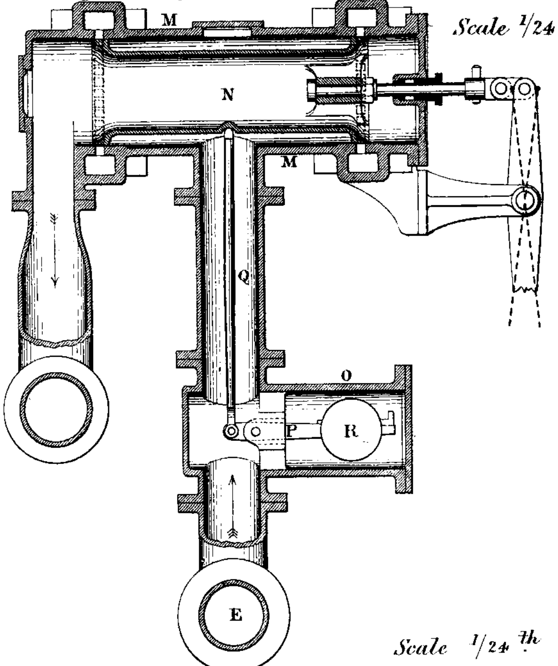


Fig. 7. *Transverse Section.*

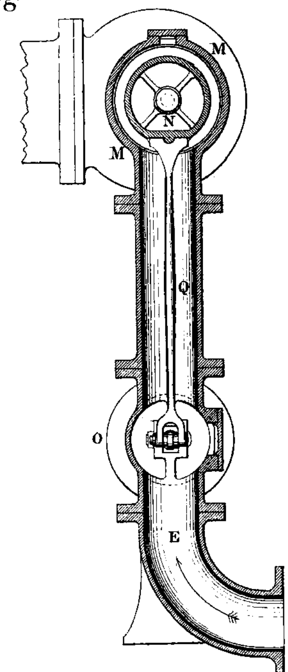
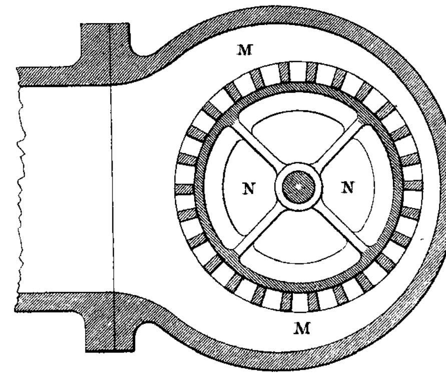


Fig. 8. *Enlarged Transverse Section through Ports.*
Scale 1/12th.



Scale 1/24th.

10 5 0 10 20 30 40 50 60 70 80 Inches.

HORIZONTAL DUPLEX HAMMER.

Longitudinal Screw connecting the two Hammer Tups.

Fig. 9. *Longitudinal Section.*

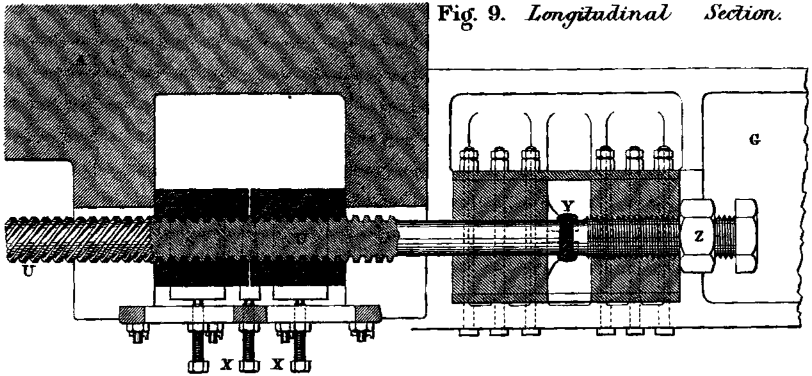


Fig. 10. *Transverse Sections.*

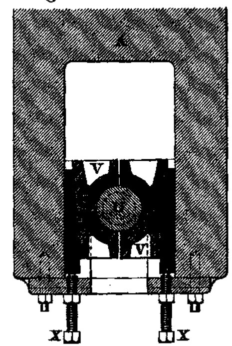


Fig. 11.

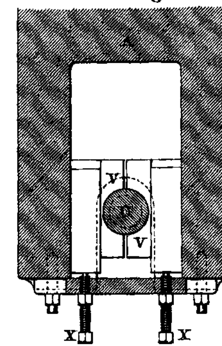


Fig. 12. *Sectional Plan.*

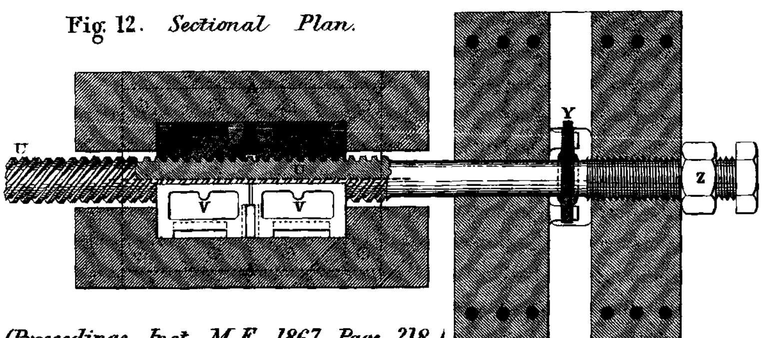
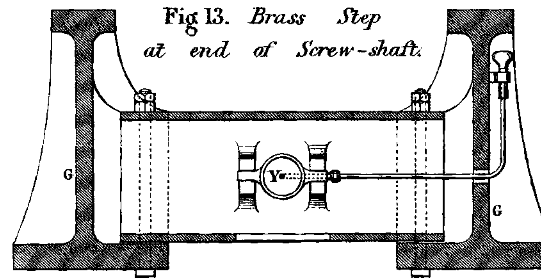
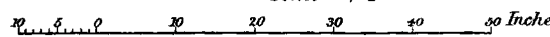


Fig 13. *Brass Step at end of Screw-shaft.*



Scale 1/24th

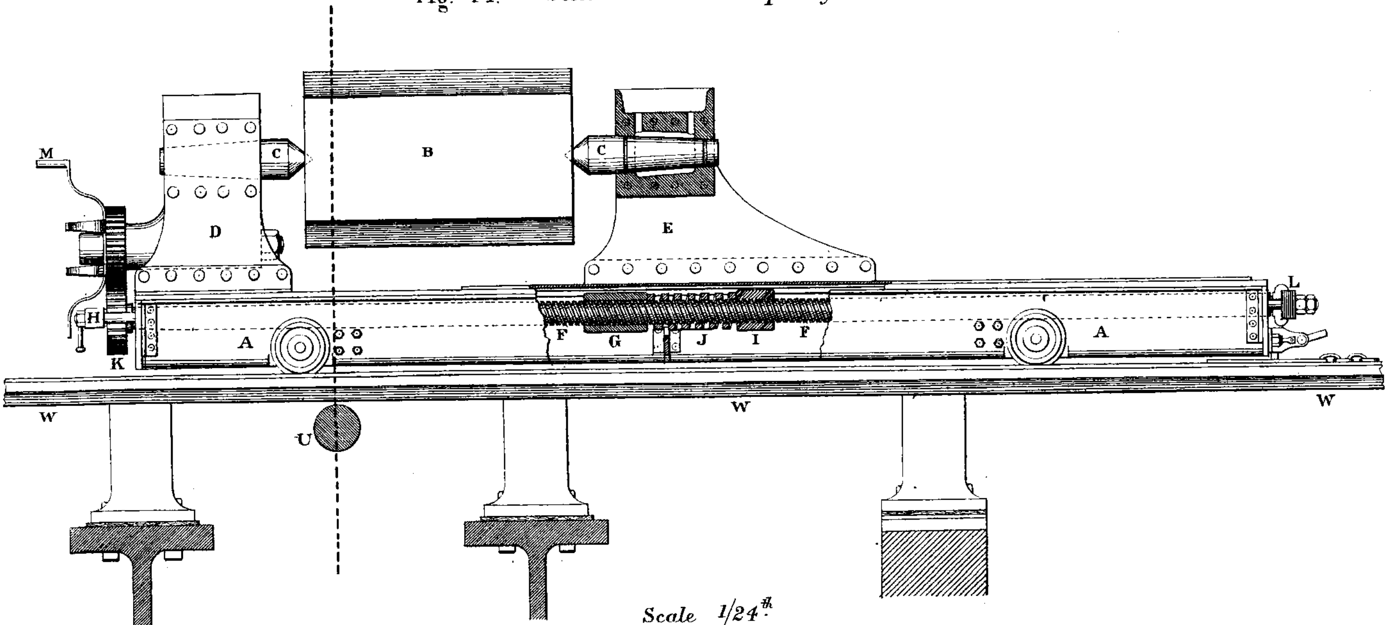


(Proceedings Inst. M.E. 1867. Page 218.)

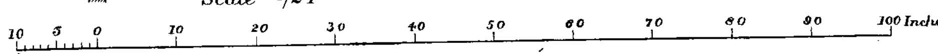
HORIZONTAL DUPLEX HAMMER.

Truck for Ordinary Ingots.

Fig. 14. *Side Elevation partly Section.*



Scale 1/24th.

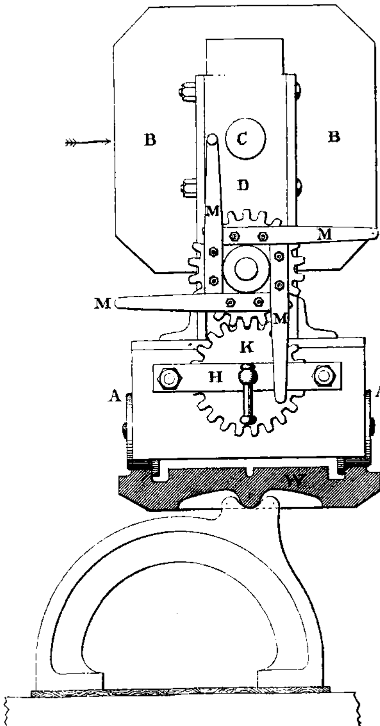


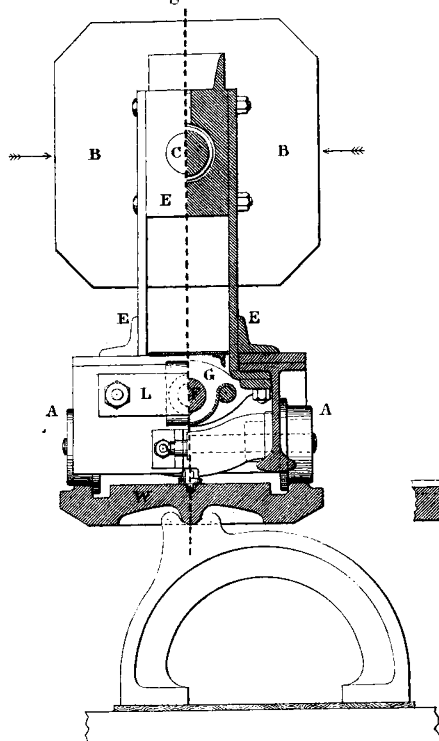
(Proceedings. Inst. M.E. 1867. Page 218.)

HORIZONTAL DUPLEX HAMMER.

Truck for Ordinary Ingots.

Fig: 15. *End Elevations.* Fig: 16.





Truck for Conical Ingots for weldless steel tyres.

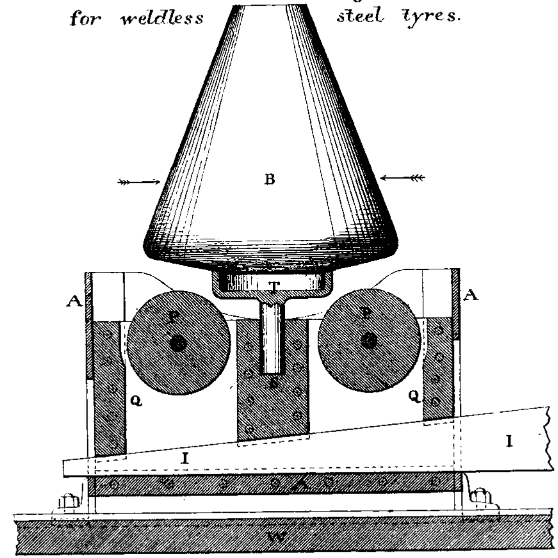


Fig: 17. *Ingot in vertical position for hammering laterally.*

(Proceedings Inst. M. E. 1867. Page 218.)

Scale 1/16th

0 10 20 30 Inches.

HORIZONTAL DUPLEX HAMMER.

Plate 72.

Truck for Conical Ingots for weldless steel tyres.
Ingot in horizontal position for hammering endways.

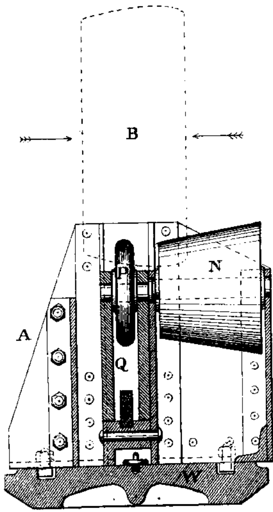


Fig. 18.
Transverse Section.

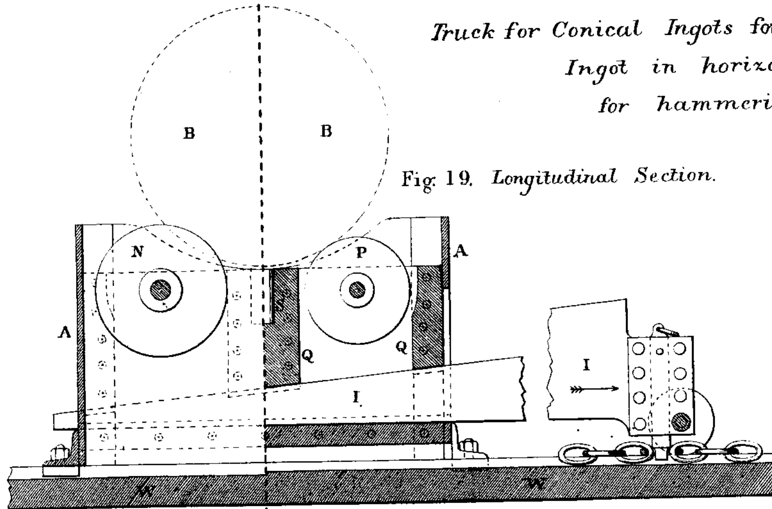


Fig. 19. *Longitudinal Section.*

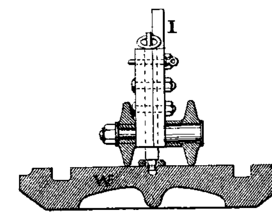
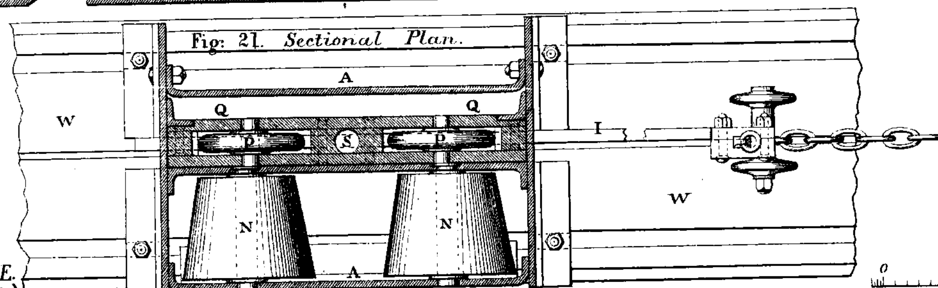


Fig. 20.
Outer end of Wedge.

Fig. 21. *Sectional Plan.*



Scale 1/16th

0 10 20 Inches.

(Proceedings Inst. M.E. 1867. Page 218.)

HORIZONTAL DUPLEX HAMMER.

Truck for Bars.

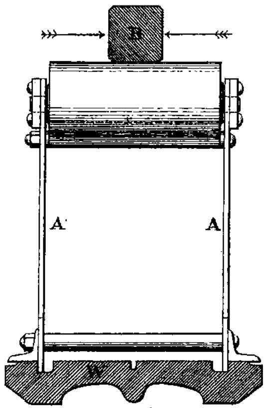


Fig. 22.
End Elevation.

Fig. 23. *Side Elevation and Section.*

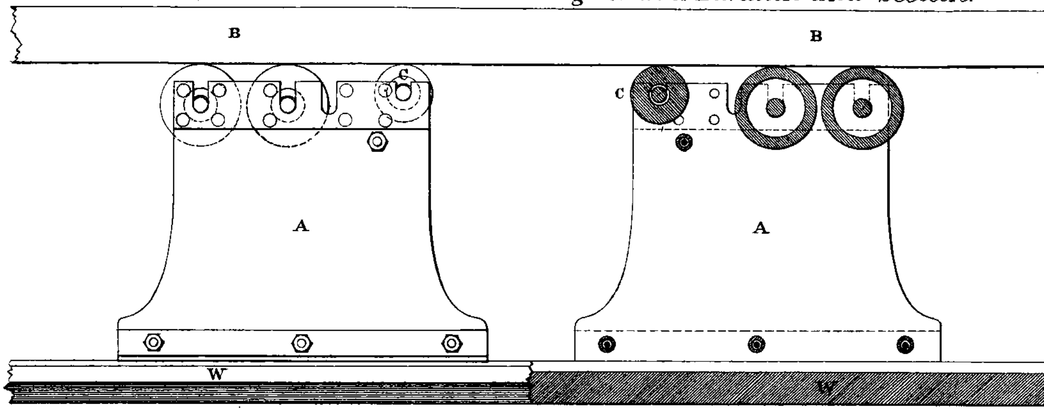
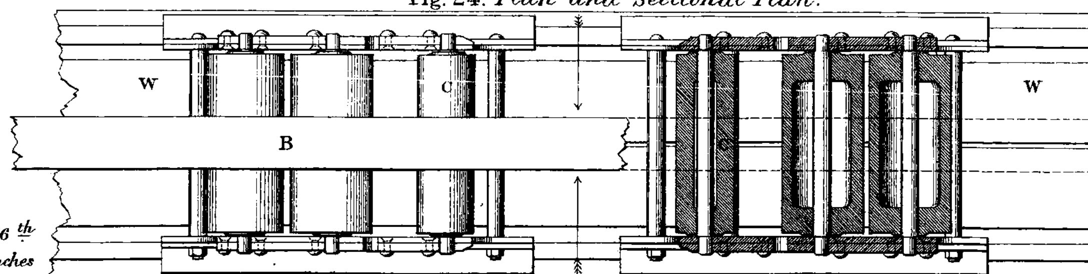


Fig. 24. *Plan and Sectional Plan.*



(Proceedings Inst. M. E. 1867. Page 218.) *Scale 1/16 th*

0 10 20 *Inches*

HORIZONTAL DUPLEX HAMMER.

Truck for Long Shafts.

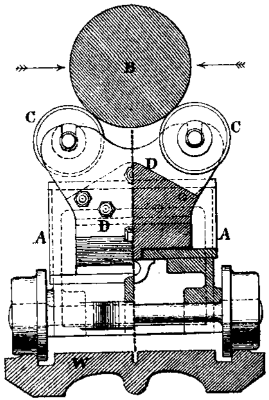


Fig. 25.
End Elevation.

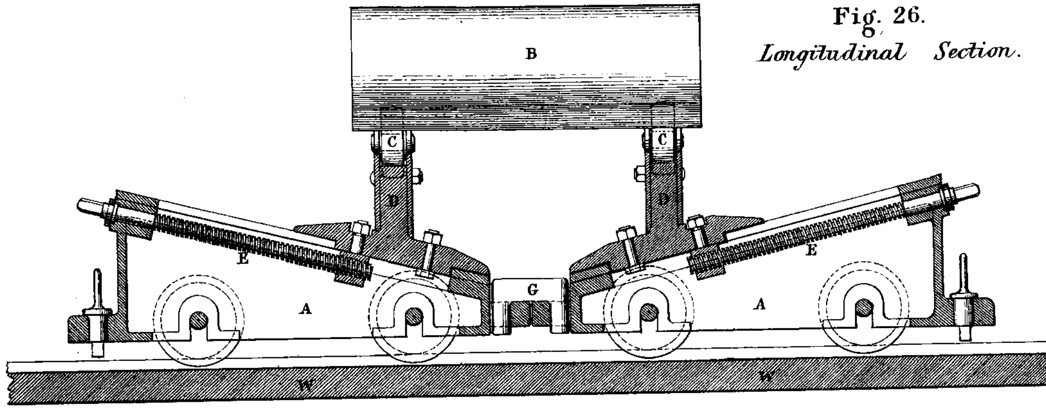
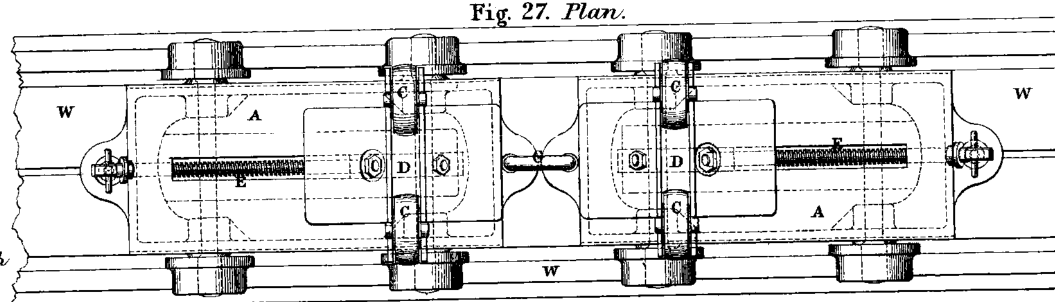


Fig. 26.
Longitudinal Section.

Fig. 27. *Plan.*



(Proceedings Inst. M. E. 1867. Page 218.) Scale 1/16th.

0 10 20 Inches.

HORIZONTAL DUPLEX HAMMER. *Plate 75.*

Peel Bar for lifting and carrying the ingots.

Fig. 28. *Elevation.*

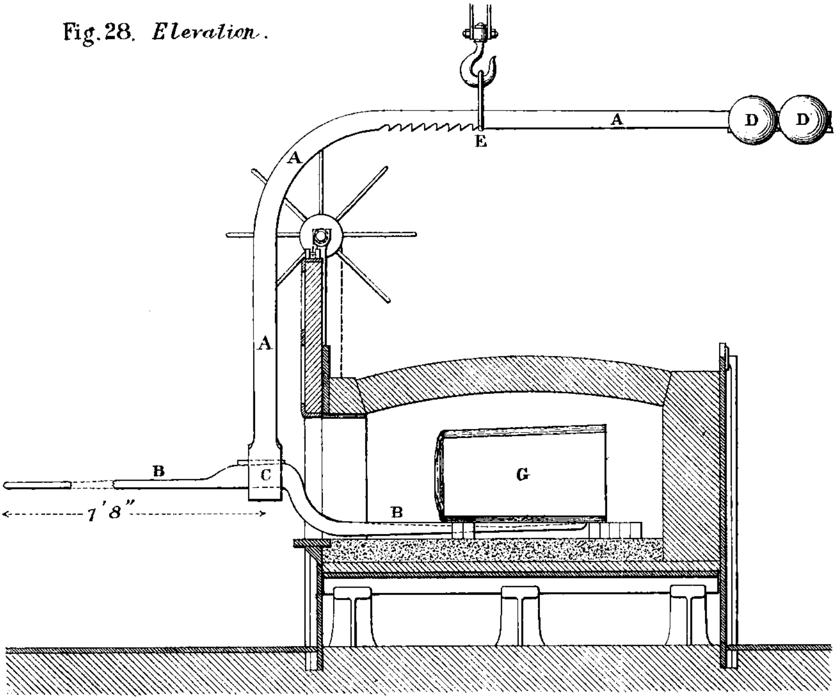
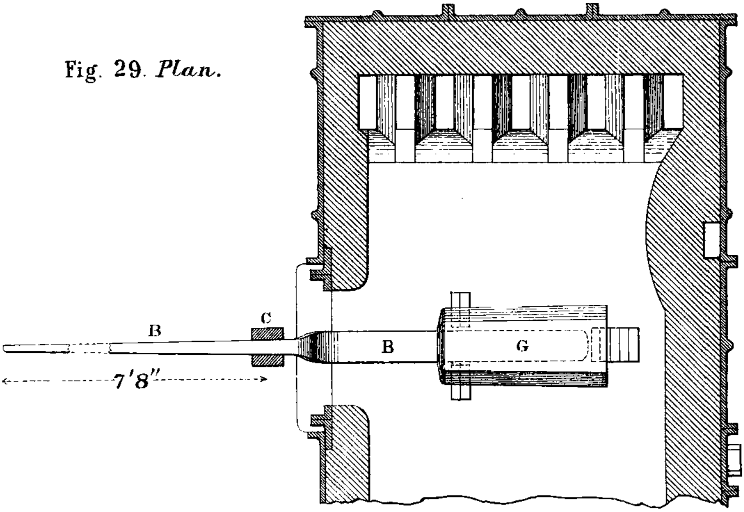


Fig. 29. *Plan.*



Scale 1/48th. 0 1 2 3 4 5 6 7 8 9 10 *Feet.*

(Proceedings Inst. M.E. 1867 Page 218.)